VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Abstract and Specification

The Abstract and Specification have been changed as shown in the Substitute Specification – Changes Shown.

In the Claims

Amend the following claims:

5. (Once Amended) The coil of claim 4, wherein the cross-sectional area of the segments that define the inactive leg portion is smaller than the cross-sectional area of the remaining segments **that define the first and second active leg portions**.

7. (Once Amended) The coil of claim 6, wherein the cross-sectional area of each of the segments that define the inactive leg portion is smaller than the cross-sectional area of each of the remaining segments **that define the first and second active leg portions**.

15. (Once Amended) The coil of claim 14, wherein the cross-sectional area of the segments that define the inactive leg portion is smaller than the cross-sectional area of the remaining segments **that define the first and second active leg portions**.

17. (Once Amended) The coil of claim 16, wherein the cross-sectional area of the segments that define the inactive leg portion is smaller than the cross-sectional area of the remaining segments **that define the first and second active leg portions**.

25. (Once Amended) The coil of c~~C~~laim 6, with the first and second active leg portions curving inward of the band, and the inactive leg portion curving outward of the band.

26. (Once Amended) The coil of c~~C~~laim 16, with the first and second active leg portions curving inward of the band, and the inactive leg portion curving outward of the band.

Claims 21-24 and 27-30 have been cancelled.

Claims 31-70 have been added.

REMARKS

Claims 1-7, 9-17, 19-20, 25-26 and 31-70 are pending. In this Response, claims 5, 7, 15, 17, 25 and 26 have been amended, claims 21-24 and 27-30 have been cancelled, and claims 31-70 have been added.

I. RESTRICTION REQUIREMENT

Claims 21-24 have been cancelled.

II. SECTION 102 REJECTIONS – RAO

Claims 6-7, 9-10, 16-17 and 19-20 are rejected under 35 U.S.C. § 102(b) as being anticipated by *Rao* (U.S. Patent 6,040,650).

Rao discloses stator windings for electric machines such as brushless and brushed type DC motors and generators.

Prior art axial gap motor 10 includes rotating permanent magnet disks 1 and 2 and stator ring 3. Permanent magnet disks 1 and 2 are separated from stator ring 3 by air gaps 4 and 5 as they rotate about axis 7 of rotor axle 12. Permanent magnet disks 1 and 2 are supported by iron rings 13 and 14, and stator ring 3 is supported by housing 15.

Stator ring 3 contains multiple sets of sector-shaped coils 20 that each contain radial sections 22a and 22b and inactive sections 26 and 27. Coils 20 with uniform cross-section conductors provide empty areas 24 that cause loss of useful area resulting in loss of torque.

Rao reduces the air gap between the magnets to increase torque by reducing the axial thickness of the stator windings. The stator windings have plural coils that are assembled arcuately adjacent to one another with the active sectors of the radial sections in an essentially coplanar configuration and having tapered conductors that increase in width in the radial direction.

Phase coil 30 includes radial sections 31a and 31b, inner section 32 and outer section 33. Radial sections 31a and 31b include tapered electrical conductors that have increasing width as they progress from the inner radius to the outer radius. Radial sections 31a and 31b can have uniform width as they extend along the inner and outer radius and run essentially in lines around the axis of rotation of the rotor. Radial sections 31a and 31b can have a constant cross-sectional area by increasing and decreasing the thickness of the conductor as the width is decreased and increased respectively to give uniform resistance to current flow. Alternatively, the thickness of the conductor can remain constant as the width expands so long as the cross-sectional area is sufficient to carry the current load.

Figure 3 illustrates the inner radius r_i, median radius r_m and outer radius r_o of the permanent magnets of the rotor superimposed on phase coil 30. Furthermore, in a typical three-phase motor, the stator contains three phase coils, such as phase coil 30, usually labeled phase A, phase B and phase C.

Thus, phase coil 30 is part of the stator.

Claims 6 recites "A voice coil for a disk drive comprising: a spiral winding" and claim 16 recites "In combination with an actuator member in a disk drive, a voice coil secured to a face of the actuator member, said voice coil comprising a continuous spiral winding."

A voice coil motor for a disk drive includes permanent magnets mounted to the base of the disk drive and a voice coil mounted to an actuator arm of the disk drive. The permanent magnets are stationary, and the voice coil pivots to radially position the actuator arm over a disk of the disk drive.

The Specification describes voice coil motors as follows:

> A voice coil motor drives the actuator arm; and this motor typically includes permanent magnets mounted to the base member and a wire and bobbin coil assembly mounted on the actuator arm. The forces generated by the interaction between the magnetic field of the coil assembly and those of the permanent magnets drive the actuator arm to various positions over the disks. (Page 1, lines 21-25).

Thus, it is abundantly clear to those skilled in the art that in a voice coil motor for a disk drive, the permanent magnets are the stator and the voice coil is the rotor.

Rao fails to teach or suggest a voice coil for a disk drive. Instead, *Rao* discloses that phase coil 30 is a stator for a three-phase motor. Thus, phase coil 30 is not a voice coil for a disk drive.

In sustaining these rejections, the Examiner asserts that *Rao* discloses a voice coil for a disk drive in Figure 3. This is clearly erroneous. Phase coil 30 is a stator, whereas a voice coil is a rotor.

Under 35 U.S.C. §102, anticipation requires that each and every element of the claimed invention be disclosed in the prior art. *Akzo N.V. v. United States International Trade Commission*, 1 USPQ 2d 1241, 1245 (Fed. Cir. 1986), *cert. denied*, 482 U.S. 909 (1987). That is, the reference must teach every aspect of the claimed invention. M.P.E.P. § 706.02.

Therefore, Applicant respectfully requests that these rejections be withdrawn.

III. SECTION 103 REJECTIONS – RAO AND YAMAMOTO ET AL.

Claims 27-30 are rejected under 35 U.S.C. § 103(a) as being unpatentable over *Rao* in view of *Yamamoto et al.* (U.S. 4,728,390). Claims 27-30 have been cancelled. Therefore, Applicant submits these rejections are moot.

IV. NEW CLAIMS

Claims 31-70 have been added. No new matter has been added.

Claims 31, 47, 51 and 67 recite "A voice coil for driving an actuator arm to various positions over a disk of a disk drive." *Rao* fails to teach or suggest that phase coil 30 is a voice coil.

V. OTHER AMENDMENTS

The Abstract, Specification and Claims have been amended to improve clarity. No new matter has been added.

VI. FEES

The fee is calculated below:

For	Claims Remaining After Amendment	Highest Number Previously Paid For		Extra Claims	Rate		Additional Fee
Total Claims	60	– 28	=	32	x $18	=	$576
Independent Claims	8	– 6	=	2	x $84	=	$168
Multiple Dep. Claim	0	0			$280	=	$0
Total Fee						=	$744

Please charge the $744 fee and charge any underpayment and credit any overpayment to Deposit Account No. 13-0016/3123-336.

VII. CONCLUSION

In view of the amendments and remarks set forth herein, the application is believed to be in condition for allowance. Should any issues remain, the Examiner is encouraged to telephone the undersigned attorney.

I hereby certify that this correspondence is being deposited with the United States Postal Service as First Class Mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231, on December 18, 2002.

D Sigmond — 12/18/02

David M. Sigmond
Attorney for Applicant

Date of Signature

Respectfully submitted,

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#8 | MARKED-UP Spec DEVICES

SUBSTITUTE SPECIFICATION – CHANGES SHOWN

"VOICE COIL FOR DISK DRIVE"

RELATED APPLICATIONS

The present application claims priority under 35 U.S.C. § 119(e) from U.S. Provisional Patent Application Serial No. 60/156,411, filed September 28, 1999, which provisional application is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

Field Of The Invention

The present invention relates to disk drives for information storage in computer systems, and more particularly to a coil assembly for a voice coil motor that drives an actuator arm of the disk drive.

Description Of The Prior Art

Most disk drive storage systems include a plurality of disks stacked onto a rotatable spindle and a corresponding number of magnetic heads that read binary digital information from the disks and write such information on them. The magnetic heads lie mounted on sliders that an actuator arm suspends over the surfaces of the disks while the actuator arm lies rotatably mounted to a base member of the disk drive.

A voice coil motor drives the actuator arm; and this motor typically includes permanent magnets mounted to the base member and a wire and bobbin coil assembly mounted on the actuator arm. The forces generated by the interaction between the magnetic field of the coil assembly and those of the permanent magnets drive the actuator arm to various positions over the disks.

The prior art includes a large number of actuator arm assemblies with various coil and magnet arrangements. Some of these assemblies include multiple layers of wire secured to the actuator arm with adhesive and a plurality of permanent magnets disposed proximate the wire. These constructions require complex fabrication procedures; they are susceptible to malfunction; and they do not allow easy miniaturization of the disk drive.

~~The coil assembly of the present invention avoids the disadvantages of the prior art constructions. It is a unique single layer structure that optimizes force vectors and mass distribution. This construction provides a planar coil that allows easy installation onto an actuator arm, minimizing the cost of manufacture and assembly and enhancing~~

~~miniaturization of the drive. It is a simple construction that provides consistent and efficient performance.~~

SUMMARY OF THE INVENTION

The coil assembly of the present invention avoids the disadvantages of the prior art constructions. It is a unique single-layer structure that optimizes force vectors and mass distribution. This construction provides a planar coil that allows easy installation onto an actuator arm, minimizing the cost of manufacture and assembly and enhancing miniaturization of the drive. It is a simple construction that provides consistent and efficient performance.

In accordance with one embodiment of this invention, a voice coil for a disk drive includes a spiral formation of winding of an electrically conductive material. This formation has a generally triangular shape with an open center. First and second active leg portions of the formation curve inward of it, and an inactive leg portion curves outward of it. The cross-sectional area of the coil varies along its length with the segments in the inactive leg portion having a smaller cross-sectional area than those of the remaining active segments. The voice coil is a laminate with the conductive layer disposed between two electrically insulating layers. It lies fixedly secured to a surface of the actuator arm. The method of making this laminate includes securing the conductive layer to an insulating layer, removing selected portions of the conductive layer to form the coil, and covering the conductive layer with another insulating layer.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of this invention, one should now refer to the embodiment illustrated in greater detail in the accompanying drawings and described below by way of an example of the invention. In the drawings:

FIG. 1 is a perspective view of a disk drive that includes the voice coil of the present invention;

FIG. 2 is a sectional view taken along line 2-2 in FIG. 1;

FIG. 3 is a sectional view taken along line 3-3 in FIG. 2; and

FIG. 4 is a sectional view taken along line 4-4 in FIG. 2.

While the following disclosure describes the invention in connection with one embodiment, one should understand that the invention is not limited to this embodiment. Furthermore, one should understand that the drawings are not to scale and that graphic symbols, diagrammatic representatives, and fragmentary views, in part, may illustrate the embodiment. In certain instances, the disclosure may not include details which are not

necessary for an understanding of the present invention such as conventional details of fabrication and assembly.

DETAILED DESCRIPTION ~~OF THE DRAWINGS~~

Turning now to the drawings and referring specifically to FIG. 1, a disk drive apparatus A includes an actuator 10 with an arm 11 which supports the voice coil assembly 12 of the present invention and a pivot assembly (not shown) which pivotally connects the actuator 10 to a base ~~B~~ of the **disk drive** apparatus A. Permanent magnets (not shown) disposed on the base ~~B~~ provide a magnetic field that interacts with the magnetic field provided by the voice coil assembly 12 to drive the actuator to various positions over a disk D of the disk drive apparatus A.

The actuator 10 of this disk drive apparatus A is a planar structure suited for use in a single disk system. However, the voice coil assembly **12**~~of the present invention 10~~ may alternatively operate in other actuator constructions, including those used in multi-disk systems. The arm or base 11 of the actuator 10 is a flat plate-like member made out of aluminum, non-magnetic steel, or any other suitable material.

The voice coil assembly 12 is a laminate structure with a bottom, electrically insulating layer 14, a middle, electrically conductive layer 15, and a top, electrically insulating layer 16. The bottom and top layers may be polymide or any other suitable material while the middle layer may be copper or other conductive material. A laminating adhesive secures one layer to another layer as well as the bottom layer to the **arm**~~actuator base~~ 11.

The conductive layer 15 is a single, spiraling trace that forms a generally triangular band 17 with an open center, first and second active legs, 15a and 15b, an inactive leg 15c, a first curved corner portion 15d connecting the first and second active leg portions, a second curved corner portion 15e connecting the first active leg portion with the inactive leg portion, and a third curved corner portion 15f connecting the second active leg portion with the inactive leg portion. The first and second active leg portions, 15a and 15b, curve inwardly of the band while the inactive leg portion 15c curves outwardly of it. (Also, although not necessary, the average radius of curvature of the first curved corner portion is greater than the average radius of curvature of the second and third corner portions; and the average radius of curvatures of the second and third corner portions is substantially the same.)

As shown in FIG. 2, the first and second leg portions of the band 17 each have a predetermined width W' while the third leg portion has a width W which is smaller in magnitude than the width of the first and second leg portions. While the spacing between

each loop of the trace ~~17~~ remains substantially the same throughout the trace, as does the height of the trace, the width varies, with the segments defining the third leg portion being substantially smaller than the segments defining the first and second leg portions (s~~S~~ee FIGS. 3 and 4).

The pivot axis of the actuator **10** lies outwardly of the **voice** coil **assembly** 12 proximate the first curved corner portion 15d. Since the third, inactive leg portion lies the furthest of the three legs from the pivot axis, it makes a substantial contribution to actuator inertia. However, it does not provide any torque in the desired direction of rotation of the actuator because it directs the force that it generates towards the actuator pivot. A reduction in the trace width (or cross-sectional area) in the third leg portion results in a reduction in mass and inertia. However, the reduction in the width is not of a magnitude that would cause a significant increase in the resistance in this portion of the trace.

As described above, the first and second leg portions curve inwardly of the **band~~trace~~** 17. This "concave" configuration aligns the electromotive force vector better than straight or convex legs. This configuration provides a higher torque constant (K_t) than does the configuration of a conventional coil with a similar size.

The method of making the voice coil assembly ~~of the present invention~~ 12 includes the following steps: securing a sheet of material (e.g., copper) that comprises the middle layer 15 to the bottom layer 1~~4~~6 (as with adhesive), removing (as with photo-etching) portions of the middle layer to form a single trace of varying cross-sectional area, and securing (as with adhesive) the **top~~third~~** layer 16 to cover the **band~~trace~~** 17. The next step in this process includes securing (e.g., with adhesive) the bottom layer 14 to the arm 11.

By way of a specific example for a 3.5 inch disk drive form factor,~~;~~ a voice coil of the present invention was constructed with a bottom polymide layer having a height of 1 mil, a middle copper layer of 1.5 mil and top polymide layer of 1 mil. The maximum width T_1 for the trace in the first and second leg portions was 5 mil with a maximum spacing S between adjacent loops of 3 mil (s~~S~~ee FIG. 3). The maximum width T_2 for the trace in the third, inactive leg portion was 3 mil with a maximum spacing S between adjacent segments of 3 mil (s~~S~~ee FIG. 4).

While the above description and the drawings disclose and illustrate one embodiment, one should understand, of course, that the invention is not limited to this embodiment. Those skilled in the art to which the invention pertains may make other modifications and other embodiments employing the principles of this invention, particularly upon considering the foregoing teachings. Therefore, by the appended

claims, the applicant intends to cover any modifications and other embodiments as incorporate those features which constitute the essential features of this invention.

ABSTRACT

A voice coil for a disk drive includes a spiral formation of winding of an electrically conductive material. This formation has a generally triangular shape with an open center. First and second active leg portions of the formation curve inward of it, and an inactive leg portion curves outward of it. The cross-sectional area of the coil varies along its length with the segments in the inactive leg portion having a smaller cross-sectional area than those of the **active leg portions**~~remaining segments~~. The voice coil is a laminate with the conductive layer disposed between two electrically insulating layers. It lies fixedly secured to a surface of a base member of the disk drive's actuator. The method of making this laminate includes securing the conductive layer to an insulating layer, removing selected portions of the conductive layer to form the coil, and covering the conductive layer with another insulating layer.